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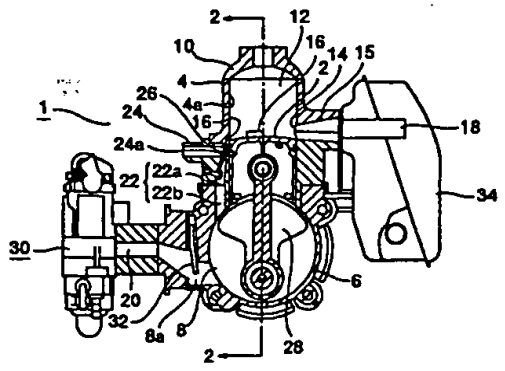
(54) STRATIFIED SCAVENGING TWO-CYCLE ENGINE

(57) The present invention relates to a stratified scavenging two-cycle engine whose simple configuration can satisfy the regulation of emission rate of THC in exhaust gas. To this end, the stratified scavenging two-cycle engine includes a cylinder (4) housing a piston (1) to be vertically slidable and having an exhaust port (14) and a scavenging port (16) in a side wall, a scavenging flow passage (22) for connection between a crank chamber (8) and the scavenging port (16), an air supply flow passage (24) connected to the scavenging flow passage (22) and supplying air through a check valve (26), and a mixture supply flow passage (20) supplying mixture to the crank chamber (8). The supply quantity ratio R = qa / Qf, which is the ratio of a supply quantity qa of air flowing through the air supply flow passage (24) to a supply quantity Qf of mixture flowing through the mixture supply flow passage (20) during a suction stroke in which pressure in the crank chamber (8) is negative, is $0.7 \leq R \leq 1.4$.

FIG. 1



EP 0 971 110 A1

Description

Technical Field

[0001] The present invention relates to a stratified scavenging two-cycle engine and, more particularly, to a stratified scavenging two-cycle engine which includes an air supply flow passage for supplying air and a mixture supply flow passage for supplying mixture separately and conducts the purification of exhaust gas by setting the ratio of flow rates flowing through the two flow passages at a predetermined ratio.

Background Art

[0002] As for a two-cycle internal combustion engine, it is generally known that part of fuel mixture fed into a cylinder flows out of an exhaust port to an exhaust flow passage with combustion gas in an exhaust stroke and is exhausted to the outside, thus causing air pollution.

[0003] As an example of solutions to the aforesaid problem, Japanese Utility Model Publication No. 55-4518 is proposed. According to the above, in an air supply flow passage which introduces air into a scavenging flow passage connected to a scavenging port owing to negative pressure in a crank chamber before starting a scavenging stroke, a variable valve is provided, the variable valve making an extremely small quantity of air including zero flow in a state of low rotation and low load operation of an engine and increasing a flow rate of air in states other than the aforesaid operation state. Thus, in a scavenging stroke in which the scavenging port is opened, air is fed into a fuel flow passage from the crank chamber to form a layer of air between combustion gas and a scavenging flow in a cylinder, thereby preventing blow-by of fuel mixture. In addition, the aforesaid air supply quantity is zero or very small at the time of low rotation and low load operation of the engine, thus preventing excessive rarefaction of fuel mixture, eliminating poor ignition, and stabilizing combustion operation. Moreover, it is described that the aforesaid air supply quantity into the cylinder increases at the time of low rotation and low load operation of the engine, thus effectively fulfilling the aforesaid operation of preventing blow-by of mixture.

[0004] As another example, Japanese Laid-open Patent No. 58-5423 is proposed. According to the above, a crank chamber compression two-cycle internal combustion engine has an exhaust port and a scavenging port in a wall on the side of a cylinder, and the exhaust port and the scavenging port are opened and closed by a wall on the side of a piston. Air is sucked into a scavenging flow passage connected to the scavenging port through an air supply flow passage due to negative pressure in the crank chamber, and sucked air is fed into the cylinder prior to fuel mixture which is sent from the crank chamber at the beginning of a scavenging stroke in which the scavenging port is opened. At this time, it is intended that the scavenging port is not opened to the crank chamber by the wall on the piston side even at an lower dead center, and that the scavenging flow passage connected to the scavenging port is at least more than twice as long as that of the conventional crank chamber compression two-cycle internal combustion engine. Moreover, the total volume of the scavenging port and the scavenging flow passage is designed to be 20 % or more of stroke volume. Thus, an initial part of scavenge which is blown to exhaust can be almost only air component with an extremely low fuel content. Accordingly, the quantity of an initial scavenge which is not mixed with fuel mixture in a crankcase can be selected so as to be optimum value according to the volume of the scavenging flow passage. When liquid fuel such as gasoline or the like is used, a large quantity of liquid fuel adhering to the wall surface of the scavenging flow passage evaporates by high speed flow of sucked air accompanied by pulsation, is mixed in the initial part of scavenge and blown to exhaust with scavenge, thereby significantly reducing the stratified scavenging effect of this system. It is described, however, that the use of fuel gas almost prevents mixing of fuel into sucked air in the scavenging flow passage.

[0005] In the aforesaid Japanese Utility Model Publication No. 55-4518, the quantity of air supply is zero or very small at the time of low rotation and low load operation of the engine, thus preventing excessive rarefaction of fuel mixture, eliminating poor ignition, and stabilizing combustion operation. Moreover, the aforesaid quantity of air supply into the cylinder increases at the time of low rotation and low load operation of the engine, thus effectively fulfilling the aforesaid operation of preventing blow-by of mixture. However, in recent years, a demand for purification of exhaust gas is increasing more and more, emission regulation is tightened up, and purification of exhaust gas at the time of the whole range of rotation of the engine as well as at the time of low rotation and low load operation of the engine is desired. For instance, in California 1999 Regulation as an example, it is demanded that the emission rate of total hydrocarbon (referred to as "THC" for short hereinafter) is not more than 50[g /HP • h]. Therefore, there is a disadvantage that it is difficult that the above regulation is satisfied only with Japanese Utility Model Publication No. 55-4518.

[0006] According to the aforesaid Japanese Laid-open Patent No. 58-5423, the scavenging flow, passage is designed to be at least more than twice as long as that of the conventional crank chamber compression two-cycle internal combustion engine, and the total volume of the scavenging port and the scavenging flow passage is designed to be 20 % or more of stroke volume. However, this is an art applied only to fuel gas. In the use of fuel gas, blow-by is prevented. On the contrary, in the use of liquid fuel such as gasoline or the like, a large quantity of liquid fuel adhering to the wall surface of the scavenging flow passage evaporates by high speed flow

of sucked air accompanied by pulsation, is mixed in the initial part of scavenge and blown to exhaust with scavenge. In addition, since the scavenging flow passage is provided outside the crankcase, there arise disadvantages that the crankcase is increased in size and the production becomes difficult.

Disclosure of the Invention

[0007] In view of the aforesaid conventional disadvantages, an object of the present invention is to provide a stratified scavenging two-cycle engine which includes an air supply flow passage for supplying air and a mixture supply flow passage for supplying mixture separately and whose simple configuration can satisfy the regulation of emission rate of THC in exhaust gas by setting the ratio of flow rates flowing through the two flow passages at a predetermined ratio.

[0008] To attain the aforesaid object, the first aspect of a stratified scavenging two-cycle engine according to the present invention is characterized in that in a stratified scavenging two-cycle engine including a piston, a cylinder housing the piston to be vertically slidable and having an exhaust port and a scavenging port in a side wall, a crankcase connected to the cylinder, a scavenging flow passage for connection between a crank chamber provided in the crankcase and the scavenging port, an air supply flow passage connected to the scavenging flow passage and supplying air through a check valve, and a mixture supply flow passage supplying mixture, to which fuel from a fuel supply means is supplied, to the crank chamber,

supply quantity ratio $R = qa / Qf$, which is the ratio of a supply quantity qa of air flowing through the air supply flow passage to a supply quantity Qf of mixture flowing through the mixture supply flow passage during a suction stroke in which pressure in the crank chamber is negative, is $0.7 \leq R \leq 1.4$. Moreover, the supply quantity ratio R may be $0.8 \leq R \leq 1.2$.

[0009] According to the aforesaid configuration, pressure in the crank chamber becomes negative with upward movement of the piston, and pressure in the scavenging flow passage connected to the crank chamber and pressure in the air supply flow passage also become negative. Thus, air is sucked into the scavenging flow passage connected with the check valve in the air supply flow passage and the crank chamber, and hence a predetermined quantity of fresh air is supplied. At this time, mixture to which fuel is supplied through the mixture supply passage is sucked into the crank chamber, and thus a predetermined quantity of mixture is supplied to the crank chamber. The supply quantity ratio R of the supply quantity qa of air supplied to the scavenging flow passage and the crank chamber to the supply quantity Qf of mixture supplied to the crank chamber is set to be $0.7 \leq R \leq 1.4$, and more preferably $0.8 \leq R \leq 1.2$. When the supply quantity ratio R supplied to the cylinder is less than 0.7, blow-by of fuel to the exhaust port increases, thereby deteriorating the THC emission rate. On the contrary, when the supply quantity ratio R supplied to the cylinder is more than 1.4, the time when mixture in the crank chamber flows into a cylinder chamber is delayed and the ratio of fuel in mixture inside the crank chamber needs to be increased. As a result, when the supply quantity ratio R is more than 1.4, fuel flows into the cylinder chamber in a liquid film state, which makes the satisfactory formation of mixture in the cylinder chamber difficult. Consequently, irregular combustion and output reduction due to delay of combustion occur and the THC emission rate deteriorates. Contrary to this, by maintaining the supply quantity ratio R within the aforesaid range of the present invention, blow-by of fuel caused when the supply quantity ratio R is less than 0.7 can be prevented and the occurrence of incomplete combustion in the cylinder caused when the supply quantity ration is more than 1.4 can be prevented. As a result, it is confirmed that the emission rate of THC in exhaust gas exhausted from the stratified scavenging two-cycle engine is not more than 50 [g / HP • h].

[0010] The second aspect of a stratified scavenging two-cycle engine according to the present invention is characterized in that in a stratified scavenging two-cycle engine including a piston, a cylinder housing the piston to be vertically slidable and having an exhaust port and a scavenging port in a side wall, a crankcase connected to the cylinder, a scavenging flow passage for connection between a crank chamber provided in the crankcase and the scavenging port, an air supply flow passage connected to the scavenging flow passage and supplying air through a check valve, and a mixture supply flow passage supplying mixture, to which fuel from a fuel supply means is supplied, to the crank chamber,

the scavenging flow passage is provided in the cylinder, or in the cylinder and the crankcase, and

volume Vs of the scavenging flow passage from an end portion on the crank chamber side to the check valve in the air supply flow passage is 70 % or more of a supply quantity qa of air flowing through the air supply flow passage at full load rated power engine speed and during a suction stroke in which pressure in the crank chamber is negative. In addition, the volume Vs may be 80 % or more of the air supply quantity qa.

[0011] According to the aforesaid configuration, similarly to the aforesaid first configuration, pressure in the crank chamber becomes negative with upward movement of the piston, whereby a predetermined quantity of fresh air is supplied to the scavenging flow passage and the crank chamber and a predetermined quantity of mixture to which fuel is supplied is supplied to the crank chamber. At this time, since the volume Vs of the scavenging flow passage is set to be 70 % or more and more preferably 80 % or more at full load rated power engine speed, the scavenging flow passage is filled with fresh air and exhaust gas within the cylinder chamber is exhausted by the fresh air, whereby the inside of the cylinder chamber is filled with the remnant of the fresh air

mixture in the crank chamber 8 goes into the cylinder chamber 12 from the scavenging port 16 through the scavenging flow passage 22, thus completing scavenge and preparing for next combustion and explosion.

[0024] Subsequently, the piston 2 starts to ascend again and the aforesaid cycle is repeated, whereby the stratified scavenging two-cycle engine 1 continuously rotates.

[0025] According to the stratified scavenging two-cycle engine 1 constructed as described above, the inside of the cylinder 12 can be scavenged by a predetermined quantity of air stored in the scavenging flow passage 22, which enables great decrease in blow-by in a scavenging stroke of mixture. Consequently there is an advantage that exhaust gas is made clearer.

[0026] The confirmed results of the above are shown in Figs. 4 and 5, and described below.

[0027] In Fig. 4, the horizontal axis represents the supply quantity ratio R(R = qa / Qf) of the air supply quantity qa [cm^3] to the mixture supply quantity Qf [cm^3], and the vertical axis represents the THC emission rate. A full line Pa shows the THC emission rate relative to the supply quantity ratio R when the scavenging flow passage volume Vs [cm^3] is 100 % of the air supply quantity qa [cm^3]. A broken line Ma shows the THC emission rate relative to the supply quantity ratio R when the scavenging flow passage volume Vs [cm^3] is 60 % of the air supply quantity qa [cm^3]. It is confirmed from the above result that the THC emission rate of not more than 50 [g / HP • h] in California Regulation in 1999 can be fully satisfied, if the air supply ratio R (R = qa / Qf) is $0.7 \leq R \leq 1.4$. It is also confirmed that even if the regulation is further tightened up in future, the THC emission rate up to not more than 35 [g / HP • h] can be fully satisfied, if $0.8 \leq R \leq 1.2$.

[0028] In Fig. 5, the horizontal axis represents scavenging flow passage volume ratio S (S = Vs / qa) of the scavenging flow passage volume Vs to the air supply quantity qa [cm^3] when the supply quantity ratio R (R = qa / Qf) of the air supply quantity qa [cm^3] to the mixture supply quantity Qf[cm^3] is 1, and the vertical axis represents the THC emission rate. A full line Sa shows the THC emission rate relative to the scavenging flow passage volume ratio S. It is confirmed from this result that the THC emission rate of not more than 50 [g / HP • h] in California Regulation in 1999 can be fully satisfied, if the scavenging flow passage volume Vs of the scavenging flow passage 22 is 70 % or more of the air supply quantity qa [cm^3]. It is also confirmed that even if the regulation is further tightened up in future, the THC emission rate up to not more than 35 [g / HP • h] can be fully satisfied, if the scavenging flow passage volume Vs is 80 % or more.

[0029] Fig. 6 shows a second embodiment of the stratified scavenging two-cycle engine 1 of the present invention. The mixture supply flow passage 20 is connected to the crank chamber 8 in the first embodiment shown in Fig. 1, while a mixture supply flow passage 35 is connected to the cylinder chamber 12 in the second embodiment. Opening and closing of the mixture supply flow passage 35 is conducted by upward and downward movement of the piston 2. It is confirmed that it is effective also in the stratified scavenging engine 1 in the second embodiment as is the case with the first embodiment.

Industrial Availability

[0030] The present invention is useful as a stratified scavenging two-cycle engine whose simple configuration can satisfy the regulation of emission rate of THC in exhaust gas.

Claims

1. A stratified scavenging two-cycle engine including a piston (1), a cylinder (4) housing said piston (1) to be vertically slidable and having an exhaust port (14) and a scavenging port (16) in a side wall, a crankcase (6) connected to said cylinder (4), a scavenging flow passage (22) for connection between a crank chamber (8) provided in said crankcase (6) and said scavenging port (16), an air supply flow passage (24) connected to said scavenging flow passage (22) and supplying air through a check valve (26), and a mixture supply flow passage (20) supplying mixture, to which fuel from a fuel supply means (30) is supplied, to said crank chamber (8),
   wherein supply quantity ratio R = qa / Qf, which is the ratio of a supply quantity qa of air flowing through said air supply flow passage (24) to a supply quantity Qf of mixture flowing through said mixture supply flow passage (20) during a suction stroke in which pressure in said crank chamber (8) is negative, is $0.7 \leq R \leq 1.4$.

2. The stratified scavenging two-cycle engine in accordance with Claim 1,
   wherein the supply quantity ratio R is $0.8 \leq R \leq 1.2$.

3. A stratified scavenging two-cycle engine including a piston (1), a cylinder (4) housing said piston (1) to be vertically slidable and having an exhaust port (14) and a scavenging port (16) in a side wall, a crankcase (6) connected to said cylinder (4), a scavenging flow passage (22) for connection between a crank chamber (8) provided in said crankcase (6) and said scavenging port (16), an air supply flow passage (24) connected to said scavenging flow passage (22) and supplying air through a check valve (26), and a mixture supply flow passage (20) supplying mixture, to which fuel from a fuel supply means (30) is supplied, to said crank chamber (8),
   wherein said scavenging flow passage (22) is pro-

vided in said cylinder (4), or in said cylinder (4) and said crankcase (6), and
wherein volume Vs of said scavenging flow passage (22) from an end portion on the side of said crank chamber (8) to the check valve (26) in said air supply flow passage (24) is 70 % or more of a supply quantity qa of air flowing through said air supply flow passage (24) at full load rated power engine speed and during a suction stroke in which pressure in said crank chamber (8) is negative.

4. The stratified scavenging two-cycle engine in accordance with Claim 3,
wherein the volume Vs is 80 % or more of the air supply quantity qa.

FIG. 1

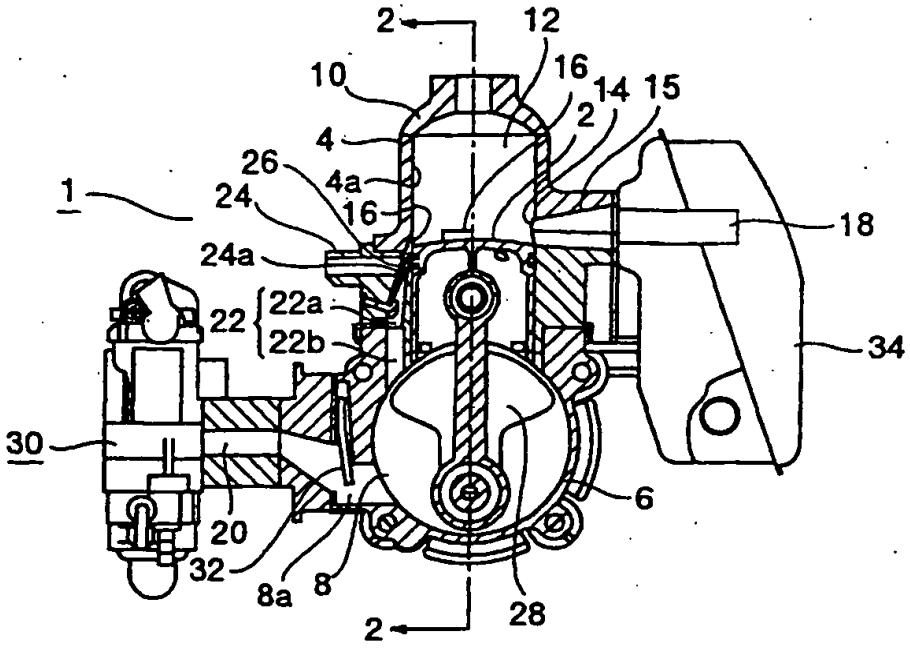

2
12
10
16
14
15
2
4
26
4a
1
24
16
18
24a
22
22a
22b
34
30
6
20
32
8a
8
28
2

FIG. 2

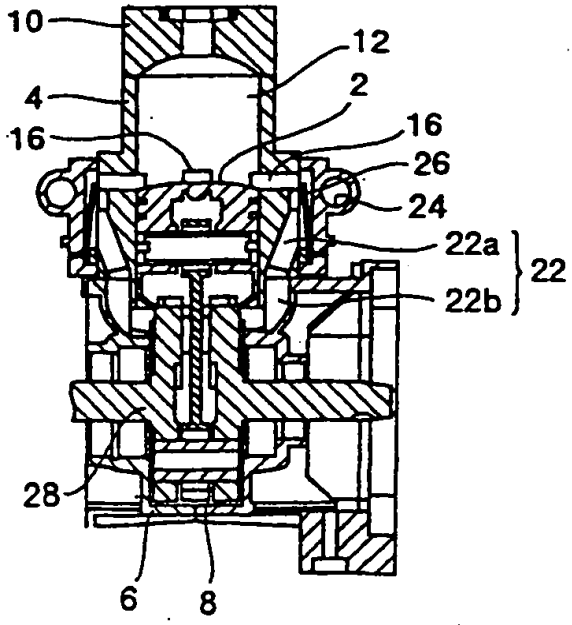

10
12
4
2
16
16
26
24
22a
22
22b
28
6
8

FIG. 3

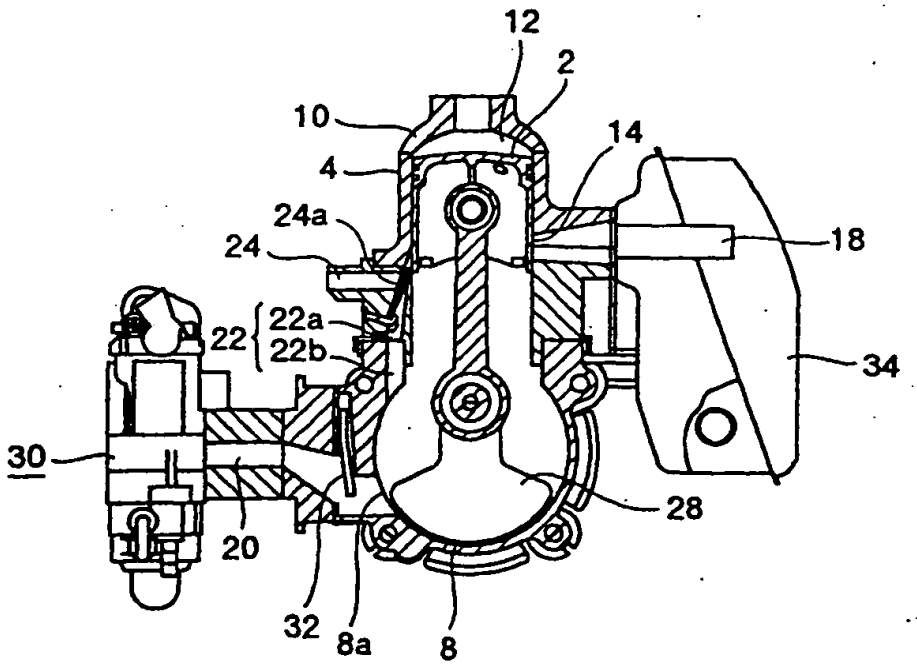


FIG. 4

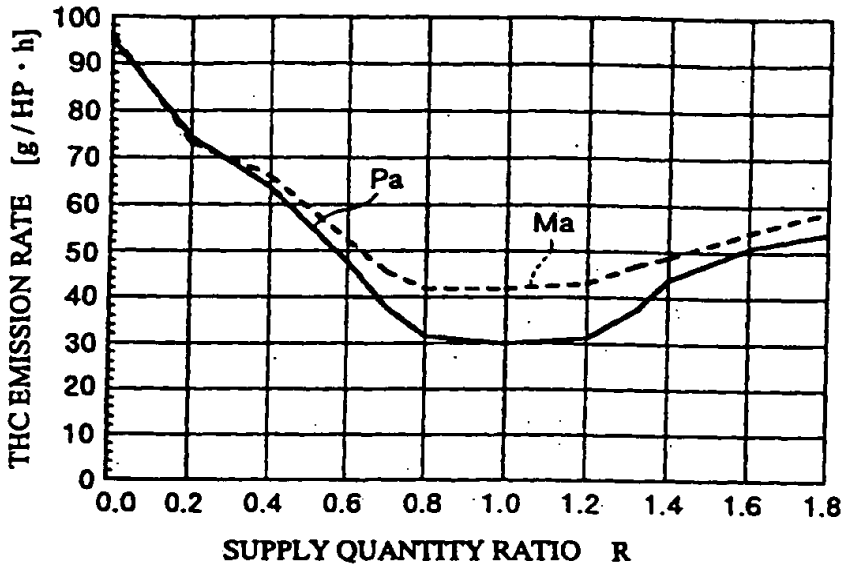

THC EMISSION RATE [g / HP · h]
100
90
80
70
60
50
40
30
20
10
0
Pa
Ma
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
SUPPLY QUANTITY RATIO R

FIG. 5

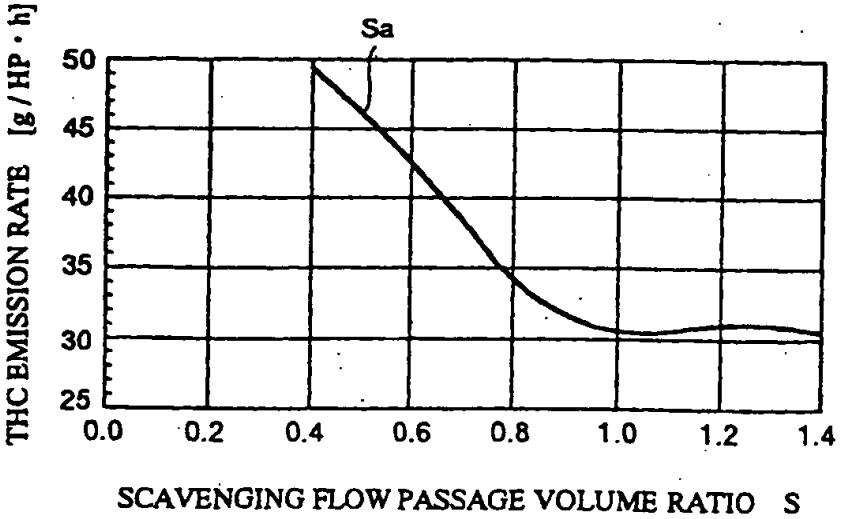
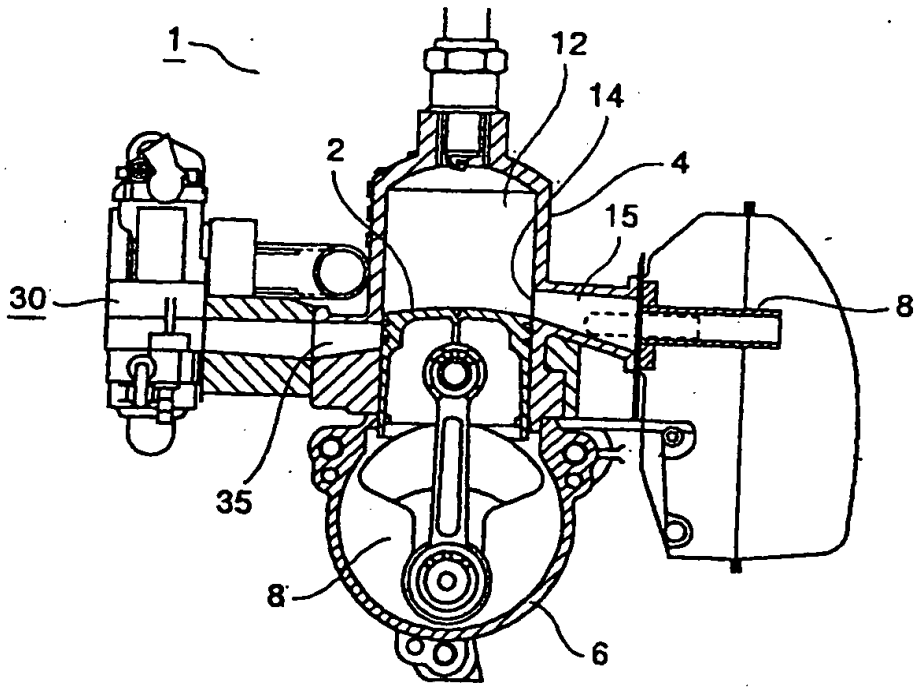

THC EMISSION RATE [g / HP · h]
Sa
50
45
40
35
30
25
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
SCAVENGING FLOW PASSAGE VOLUME RATIO S

FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/04360

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] F02B25/16, F02B23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] F02B25/16-25/22, F02B23/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1998 Toroku Jitsuyo Shinan Koho 1994-1998
Kokai Jitsuyo Shinan Koho 1971-1998 Jitsuyo Shinan Toroku Koho 1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P	JP, 09-125966, A (Komatsu Zenoah Co.), 13 May, 1997 (13. 05. 97), Column 1, lines 2 to 22 ; Fig. 1 (Family: none)	1-4
P	JP, 10-121974, A (Applicant), 12 May, 1998 (12. 05. 98), Column 1, lines 2 to 23 (Family: none)	1-4
Y	JP, 61-053520, U (Hino Motors, Ltd.), 10 April, 1986 (10. 04. 86) (Family: none)	1-4
Y	JP, 61-147330, U (Takao Odagiri), 11 September, 1986 (11. 09. 86) (Family: none)	1-4
Y	JP, 51-160721, U (Suzuki Motor Corp.), 21 December, 1976 (21. 12. 76) (Family: none)	1-4
Y	JP, 53-082615, U (Ryosuke Okudaira), 8 July, 1978 (08. 07. 78) (Family: none)	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 December, 1998 (16. 12. 98)	6 January, 1999 (06. 01. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)